VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This fourth quarterly report summarizes progress under the VELA Network and Automatic Processing Research Program, Contract No. F08606-74-C-0033, during the period 1 August 1974 to 31 October 1974. Work in the following areas is summarized:

- VLPE Station Evaluation
- Network Analysis

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20. continued

- Signal Detection
- Signal Estimation
- First-Zone Discrimination
- Seismic Surveillance System

VELA NETWORK EVALUATION AND AUTOMATIC PROCESSING RESEARCH

QUARTERLY REPORT NO. 4

1 AUGUST 1974 TO 31 OCTOBER 1974

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SECTION I
INTRODUCTION AND SUMMARY

This fourth quarterly report summarizes progress made during the quarter from 1 August 1974 to 31 October 1974 on the VELA Network Evaluation and Automatic Processing Research program being carried out by Texas Instruments Incorporated at the Seismic Data Analysis Center in Alexandria, Virginia. The six tasks of the program are:

- Evaluation of the Very Long Period Experiment (VLPE) stations
- Investigation of the detection and discrimination characteristics of a seismic network using VLPE, NORSAR, and ALPA data
- Investigation of signal detection techniques
- Investigation of signal estimation techniques
- Investigation of discrimination techniques using first-zone data
- Simulation of a seismic surveillance system consisting of a network of seismic stations.

The software required for the first two tasks was developed under Contract F33657-67-C-1063. Most of the software for the remaining tasks is being generated under this contract.

All data processing and interpretation for the VLPE evaluation and network analysis tasks have been completed during the past quarter. A

report dealing with the evaluation and application of matched filters and the three component adaptive processor has been submitted for approval. Another report dealing with the estimation of detection thresholds using noise statistics has also been submitted for approval.

An analysis of the ambient noise field at each of the VLPE stations has been completed, and the detection and discrimination capabilities of the VLPE stations, the VLPE network, and the VLPE-ALPA-NORSAR combined network have been determined. Reports on these subjects are in preparation and will be submitted for approval this quarter.

Processing of the Korean array data using the Fisher detector program was completed. A report is being prepared.

The new adaptive beamforming program has been checked out on long-period data from ALPA, NORSAR, and LASA, and on short-period data from KSRS. A report is in preparation.

Preliminary investigation of discriminant parameters for first-zone events recorded at NORSAR was completed. A report is being prepared and will be submitted this quarter.

Simulators for the elements of a seismic surveillance system have been developed. A report on a study of parameter updating by feedback is being prepared. The study of the role of interactive processing in surveillance systems was completed, and a report is being prepared. Software for interactive processing has been developed and evaluated, and a report is in preparation.

SECTION II
VLPE EVALUATION AND NETWORK ANALYSIS

A. CURRENT STATUS

During the past quarter, all data processing and interpretation for the VLPE evaluation and network analysis tasks have been completed.

Under the VLPE evaluation task a comparative evaluation of matched filters and of the three component adaptive processor using VLPE data was completed. Signal-to-noise ratio improvements, detection level improvements, and surface-wave magnitude computations for events not detected by standard bandpass filter were studied, and a comparison of these data enhancement techniques was made. A report on this subject has been submitted for approval.

Another area of work concerned estimation of detection thresholds from ambient noise levels. The conditions for the validity of this method, and the parameters involved, were investigated. The method was successfully applied to noise data from several VLPE stations. A report on this method has been submitted for approval.

Work has been completed on a study of the noise characteristics of eleven VLPE stations. About 1500 hours of noise data were processed and analyzed for short- and long-term vertical noise trends. Three component spectra and two component coherence spectra were also calculated. A report on this subject is in preparation.

The network evaluation task considered the detection and discrimination capabilities of the individual VLPE stations, the VLPE network,

and the VLPE-ALPA-NORSAR combined network. A total of about 6000 event-station combinations was used in both the evaluation of the individual VLPE stations and the VLPE network. About 2500 additional event-station combinations were used in the VLPE-ALPA-NORSAR combined network evaluation. Detection thresholds, M_s versus m_b relationships, LQ/LR ratios, interfering event statistics, and data quality were considered for various combinations of the networks studied. A report is also in preparation for this task.

B. FUTURE PLANS

The major effort in the future will be concerned with the completion of the two reports in preparation, and submitting them for approval.

SECTION III
SIGNAL DETECTION TECHNIQUES

A. CURRENT STATUS

Approximately 185 events recorded at the Korean Seismic Research Station (KSRS) with bodywave magnitudes up to 5.8 were examined with both the Fisher and conventional power detectors. This set of events constitutes all of the events recorded at KSRS which are presently available. The peak response of each detector was used to draw curves of detection probability versus magnitude, with detector threshold as a parameter. Five one-hour signal free noise samples also were examined, and the number of responses at each threshold used to find false alarm rates. The Fisher detector false alarm rate was highly variable from day to day, while the conventional power detector false alarm rate was less variable.

B. FUTURE PLANS

All data processing has been completed and a report of the results is being prepared. This report will be submitted for approval next month.

SECTION IV
SIGNAL ESTIMATION TECHNIQUES

A. CURRENT STATUS

The adaptive beamforming program (ABF) has been checked out on long-period data from ALPA, NORSAR, and LASA, and on short-period data from KSRS. When the ABF was applied to ALPA data, signal-to-noise ratio gains of up to 8 dB have been achieved.

A few measurements have been made on synthetically formed interfering events at ALPA. The results indicate that a greater signal-to-noise ratio gain was achieved by increasing the time separation between events and by increasing the off-azimuth to on-azimuth signal energy ratio. For on-azimuth events seen on the beamsteer output, the ABF cancelled the on-azimuth event exactly by adding the adaptive output from the interfering event 180 degrees out of phase. This problem, if serious for real data, can be eliminated by use of a Wiener multichannel filter.

A signal-to-noise ratio gain of 5 dB was found on short-period KSRS data. No mutual cancellation has been observed in this case.

The processing of the event ensembles for the envelope detector study was completed this quarter. A report has been written and is being reviewed in house.

B. FUTURE PLANS

Data processing required to fully evaluate the ABF and resolve the problems indicated above will be undertaken in the future. A report of these results will be prepared.

SECTION V
FIRST-ZONE DISCRIMINATION TECHNIQUES

A. CURRENT STATUS

Preliminary investigation of discrimination parameters for 40 first-zone events recorded at NORSAR was completed. Only thirty events, including presumed explosions, were within 20 degrees of NORSAR. The long-period portion of the analysis was severely limited due to errors on the library tapes. Only six events common to the short-period ensemble were edited. Short-period NORSAR data for thirty-three additional first-zone events have been ordered but as yet have not arrived.

Measurements on the available data included estimates of M_s, m_b, phase amplitudes for both short- and long-period data, phase travel times, and phase energies. The most promising first-zone discriminant for this small data set appears to be the short-period P/S energy ratio. When this ratio is plotted as a function of distance, complete separation between earthquakes and presumed explosions was achieved. A preliminary report is being prepared.

B. FUTURE PLANS

The preliminary report concering the present analysis of thirty first-zone events will be completed and submitted for approval.

SECTION VI
SYSTEM STUDY

A. CURRENT STATUS

The system study presently has four tasks. They are: the development of a simulator for a seismic surveillance system, the analytic study of parameter updating in the simulator by feedback of seismic information, a study of the role of interactive processing in surveillance systems, and the development and application of interactive processing in seismic analysis.

Simulators have been completed for station detection processors for a realistic earth model and for a representative communication system. A separate driver program is being used to evaluate the communications system. A detection association processor is currently being developed. The study of parameter updating by feedback was completed and a report on the results is being prepared. The study of the role of interactive processing in surveillance systems was also completed, and a report is being prepared. Software for interactive processing has been completely developed, including documentation. It is capable of performing interactively many of the standard measurements on long-period data. An evaluation of the interactive system has been conducted, directed toward assessment of the effectiveness of the system in a surveillance mode, and a report is in preparation.

B. FUTURE PLANS

The station detection processors recently developed will be evaluated on output from the earth model. Evaluation of the communications

system will continue, independent of the rest of the system. Evaluation of the entire system, less the communications system, will be undertaken.